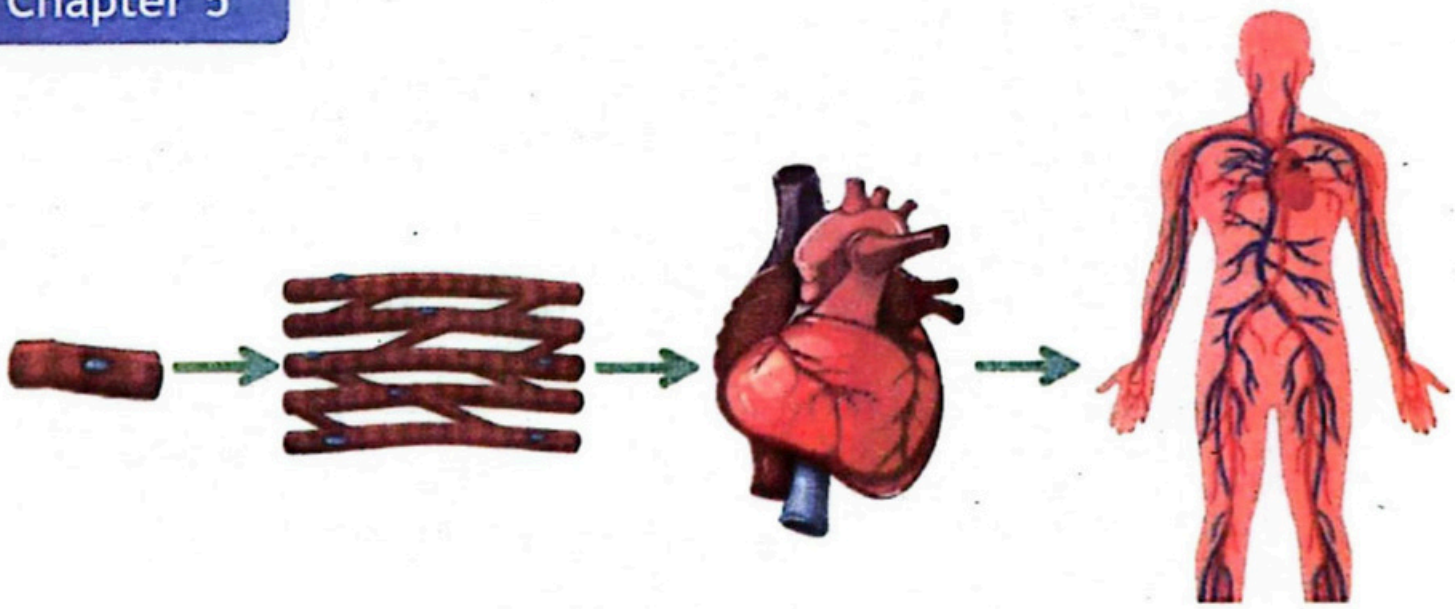
Chapter 5



TISSUES, ORGANS AND ORGAN SYSTEMS

SLOs: After completing this lesson, the student will be able to:

1. Describe the concept of emergent properties as gain in functionalities and how it applies to the following:
   a. going from sub cellular organelles to cells
   b. going from cells to tissues
   c. going from tissues to organs
   d. going from organ to systems
   e. going from organ systems to living organisms
2. Distinguish between tissues, organs and systems, with examples from animals and plants.
3. Enlist the different types of tissues come together to form the stomach organ in the human body.
4. Discuss the organ systems come together to form the human body.
5. Describe the advantages of homeostasis.
6. Discuss the various organs and systems of the human body work to maintain homeostasis.
7. Discuss the different types of tissues come together to form the leaf.
8. Explain plant physiology in terms of structure and roles of various plant organs.

5.1 THE LEVELS OF ORGANIZATION

Whether we study an individual organism or the world as whole, we can identify a pattern of increasing complexity. Cell organelles are the parts that make up a **cell**, like the nucleus, ribosomes and the mitochondria. Each individual organelle has a specific role to play, and when combined, multiple organelles will form a single cell.

The cells in complex multicellular organisms like human beings are organized into **tissues** i.e., groups of similar cells that work together on a specific task. **Organs** are structures made up of two or more tissues organized to carry out a particular function, and groups of organs with related functions make up different **organ systems.**

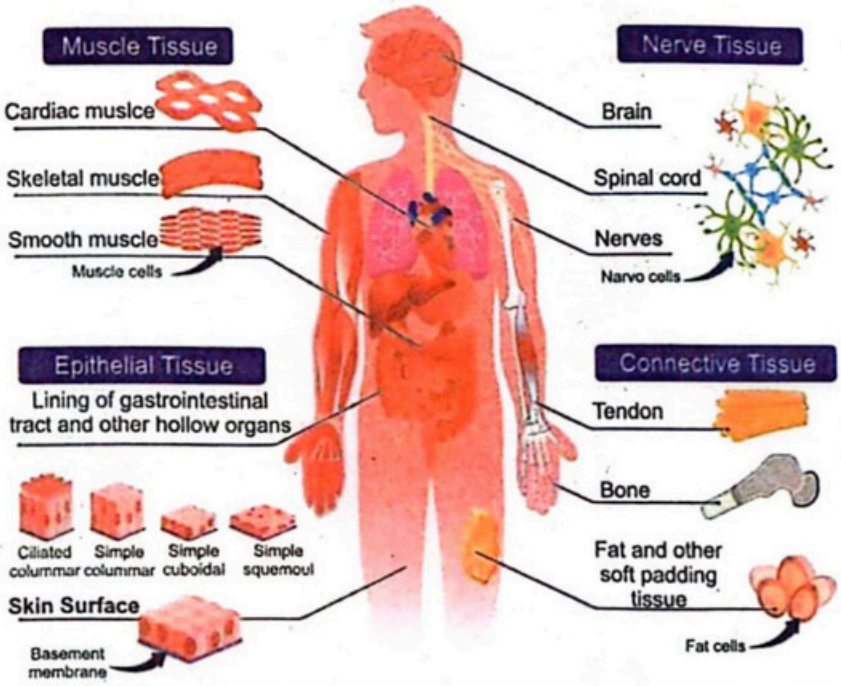
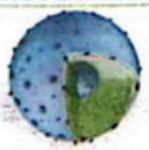


Figure 5.1: Types of tissues in humans

At each level of organization—cells, tissues, organs, and organ systems—structure is closely related to function. For instance, the cells in the small intestine that absorb nutrients look very different from the muscle cells needed for body movement. The structure of the heart reflects its job of pumping blood throughout the body, while the structure of the lungs maximizes the efficiency with which they can exchange gases.

Table 5.1: The Levels of Organization and their explanation

Level of Organization	Explanation	Example
 Atomic Level	Atoms are defined as the smallest unit of an element that still maintains the property of that element.	Carbon, Hydrogen, Oxygen
 Molecular Level	Atoms combine to form molecules which can have entirely different properties than the atoms they contain.	Water, DNA, Carbohydrates
 Organelle Level	Biomolecules assemble in a specific way to form organelle. Organelles are sub-cellular structure.	Nucleus, ribosomes

 Cellular Level	Cells are the smallest unit of life. Cells are enclosed by a membrane or cell wall and in multicellular organisms often perform specific functions	Muscle cell, Skin cell, Neuron
 Tissue Level	Tissues are groups of cells with similar functions	Muscle, Epithelial, Connective
 Organ Level	Organs are two or more types of tissues that work together to complete a specific task.	Heart, Liver, Stomach
 Organ System Level	An organ system is group of organs that perform related functions.	Digestive System, Circulatory System
 Organism Level	An organism has several organ systems that function together.	Human

5.1.1. Organs

Organs, such as the heart, the lungs, the stomach, the kidneys, the skin, and the liver, are made up of two or more types of tissues organized to serve a particular function. For example, the heart pumps blood, the lungs bring in oxygen and eliminate carbon dioxide, and the skin provides a barrier to protect internal structures from the external environment.

Most organs contain all four tissue types. The layered walls of the

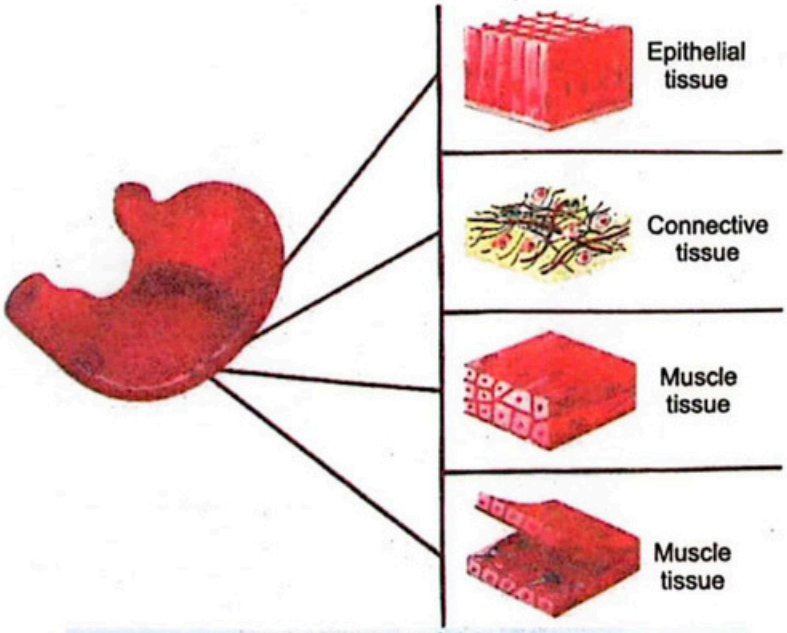


Figure 5.2 Stomach as an organ

stomach provide a good example of how tissues form an organ. The inside of the stomach is lined by epithelial cells which secretes mucus, hydrochloric acid and pepsin enzyme. Around the epithelial layer are layers of connective tissue and smooth muscle, along with glands, blood vessels, and neurons. The smooth muscle contracts to move food through the gut. Connective tissues support the tissues of the mucosa and connect it to the muscular layer. The blood supply of the submucosa provides nutrients to the wall of the stomach. Nervous tissue in the submucosa controls smooth muscle contraction and secretion of digestive substances.

5.1.2. Organ systems

Organs are grouped into **organ systems**; in which they work together to carry out a particular function for the organism.

For example, the heart and the blood vessels make up the cardiovascular system. They work together to circulate the blood, bringing oxygen and nutrients to cells throughout the body and carrying away carbon dioxide and metabolic wastes. Another example is the respiratory system, which brings oxygen into the body and gets rid of carbon dioxide. It includes the nose, mouth, pharynx, larynx, trachea, and lungs.

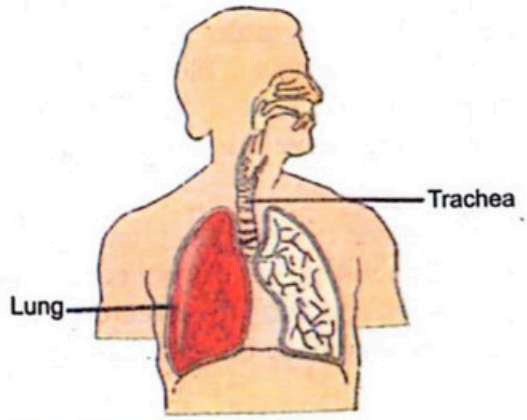


Figure 5.3 Respiratory system

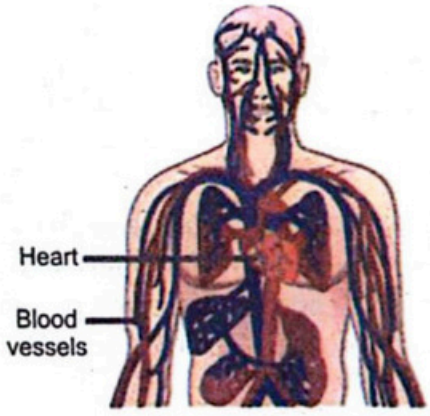


Figure 5.4 Circularity system

5.1.3. Organ systems work together

Just as the organs in an organ system work together to accomplish their task, the different organ systems also cooperate to keep the body running.

For example, the respiratory system and the circulatory system work closely together to deliver oxygen to cells and get rid of the carbon dioxide that these cells produce. The circulatory system picks up oxygen in the lungs and drops it off in the tissues, then performs the reverse function for carbon dioxide. The lungs expel the carbon dioxide and bring in new oxygen-containing air. Only when both systems are working together can oxygen and carbon dioxide be successfully exchanged between cells and environment.

5.2 HOMEOSTASIS

The tendency to maintain a stable, relatively constant internal environment is called **homeostasis**. The body maintains homeostasis for many factors for example, temperature, the concentration of various ions, pH and the concentration of glucose. If these values get too high or low, you can end up getting very sick.

Homeostasis is maintained at many levels, not just the level of the whole body as it is for temperature. For instance, the stomach maintains a pH that's different from that of surrounding organs, and each individual cell maintains ion concentrations different from those of the surrounding tissue fluid. Maintaining homeostasis at each level is key to maintaining the body's overall function. So, how is homeostasis maintained?

5.2.1. Maintaining homeostasis

Biological systems like those of your body are constantly being pushed away from their balance points. For instance, when you exercise, your muscles increase heat production, pushing your body temperature upward. Similarly, when you drink a glass of fruit juice, your blood glucose goes up. Homeostasis is the ability of your body to detect and oppose these changes and work to maintain balance points.

5.2.2. Homeostatic responses in temperature regulation

If you get either too hot or too cold, sensors in the periphery and the brain tell the temperature regulation centre of your brain—in a region called the hypothalamus—that your temperature has strayed from its set point.

For instance, if you've been exercising hard, your body temperature can rise *above* its set point, and you'll need to activate mechanisms that cool you down. Blood flow to your skin increases to speed up heat loss into your surroundings, and you might also start sweating so the evaporation of sweat from your skin can help you cool off. Heavy breathing can also increase heat loss.

How does this work? First, high temperature will be detected by **sensors**—primarily nerve cells with endings in your skin and brain—and relayed to a temperature-regulatory **control centre** in your brain. The control centre will process the information and activate **effectors**—such as the sweat glands—whose job is to oppose the stimulus by bringing body temperature down.

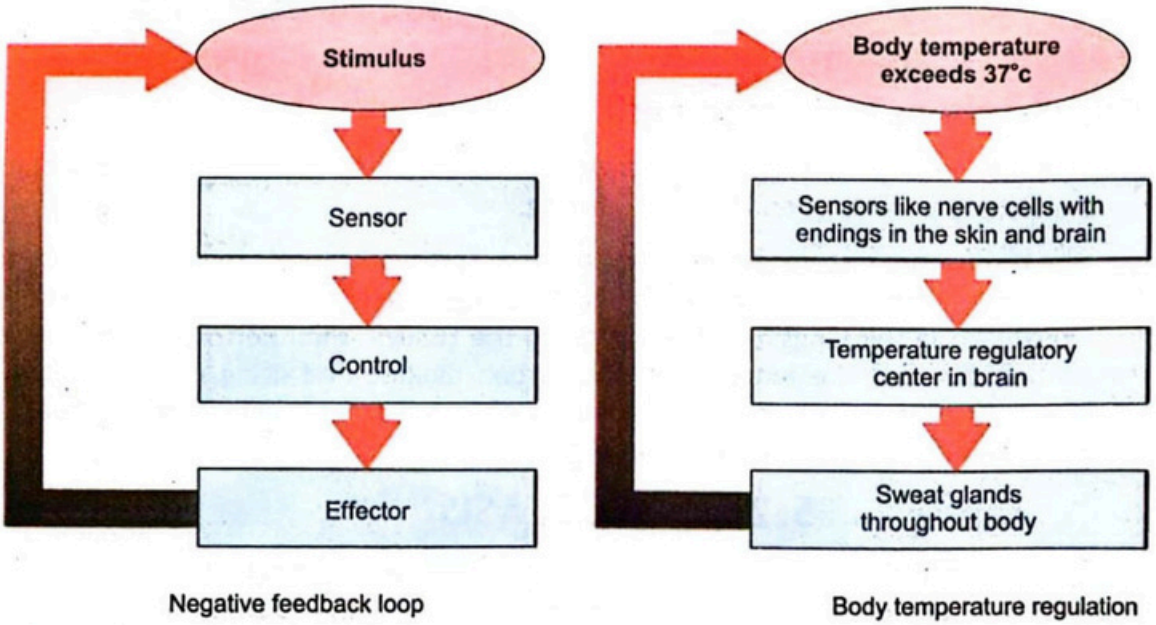


Figure 5.5: Homeostatic response in temperature regulation

Table 5.2: Major organ systems of the human body and homeostasis

Organ system	Function	Organs, tissues, and structures involved	Role in Homeostasis
Cardiovascular	Transports oxygen, nutrients, and other substances to the cells and transports wastes, carbon dioxide, and other substances away from the cells	Heart, blood, and blood vessels	help stabilize levels of gases and wastes, body temperature and pH
Lymphatic	Defends against infection and disease and transfers lymph between tissues and the blood stream	Lymph, lymph nodes, and lymph vessels	Maintain tissue fluid homeostasis
Digestive	Processes foods and absorbs nutrients, minerals, vitamins, and water	Mouth, salivary glands, oesophagus, stomach, liver, gallbladder, exocrine pancreas, small intestine, and large intestine	Maintains levels of nutrients in blood
Endocrine	Provides communication within the body via hormones and directs long-term change in other organ systems to maintain homeostasis	Pituitary, pineal, thyroid, parathyroid, endocrine pancreas, adrenals, testes, and ovaries.	Maintains balance of many blood components like glucose, water, calcium etc.
Integumentary	Provides protection from injury and fluid loss and provides physical defence against infection by microorganisms;	Skin, hair, and nails	Involved in temperature regulation
Muscular	Provides movement and support	Skeletal, cardiac, and smooth muscles	Helps in temperature regulation by heat production

Table 5.2: Major organ systems of the human body and homeostasis

Organ system	Function	Organs, tissues, and structures involved	Role in Homeostasis
Nervous	Collects, transfers, and processes information and directs short-term change in other organ systems	Brain, spinal cord, nerves, and sensory organs—eyes, ears, tongue, skin, and nose	Maintains homeostasis by rapidly controlling body functions
Respiratory	Delivers air to sites where gas exchange can occur	Mouth, nose, pharynx, larynx, trachea, bronchi, lungs, and diaphragm	Controlling the balance of oxygen and carbon dioxide in the body
Skeletal	Supports and protects soft tissues of the body; provides movement at joints; produces blood cells; and stores minerals	Bones, cartilage, joints, tendons, and ligaments	By regulating the level of calcium and other minerals in the blood (storing or releasing them from bones)
Urinary	Removes excess water, salts, and waste products from the blood and body and controls pH	Kidneys, ureters, urinary bladder, and urethra	By regulating levels of water, salts, H+ and wastes in blood
Immune	Defends against microbial pathogens—disease-causing agents—and other diseases	Leukocytes, tonsils, adenoids, thymus, and spleen	By removing pathogens, fighting infections and helping in healing

5.3 PLANT TISSUES

Plants are multicellular eukaryotes with tissue systems. Plant tissues are composed of cells that are similar and perform a specific function. Different tissues combine to form organs. Each organ itself is also specific for a particular function together making up the tissue systems.

Plant tissues differentiate into three main types: dermal, ground, and vascular tissue. **Dermal tissue** covers and protects the plant. The **ground tissue** serves as a site for photosynthesis,

provide support, and helps to store water and sugars. The **vascular tissue** transports water, minerals, and sugars to different parts of the plant.

5.3.1. Plant organs and organ systems relation with plant physiology

Plant tissues form **organs** (such as leaves, stems, or roots), each of which perform a specific set of functions. Leaves perform photosynthesis. Stems support the plant and transport substances.

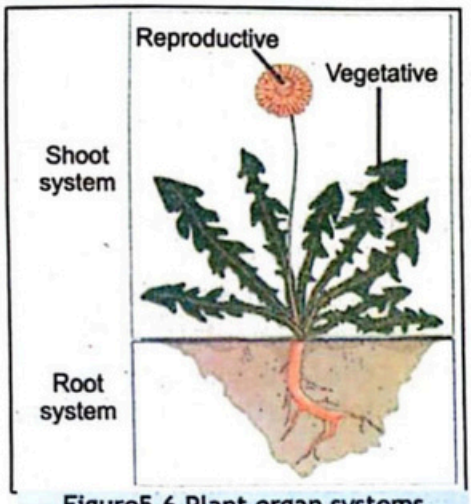


Figure5.6 Plant organ systems

Together, organs often work to form **organ systems.** Vascular plants have two distinct organ systems: a shoot system, and a root system. The **shoot system** consists of two portions: the vegetative (non-reproductive) parts of the plant, such as the leaves and the stems, and the reproductive parts of the plant, which include flowers and fruits. The shoot system generally grows above ground, where it absorbs the light needed for photosynthesis. The **root system**, which is usually underground anchors the plant into the ground, absorbs water and minerals, and serves as a storage site for food.

5.3.2. Structure and Functions of Cells of a Leaf

Leaves are thin, flat organs responsible for photosynthesis in the plants. It develops laterally at the node. It is an important part of the shoot system as it performs photosynthesis and transpiration. Leaf cells need water, carbon dioxide and light for photosynthesis and oxygen for respiration. Leaves transfer the synthesized food to other parts of the plant. So, there are varieties of functions and accordingly there are varieties of cells, in the leaf. Each type of cell performs a special function.

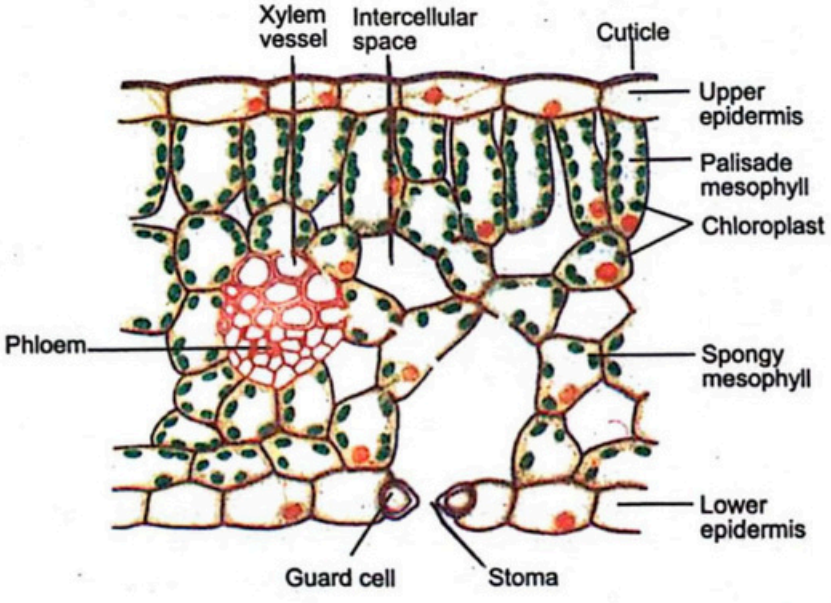


Fig 5.7 : Transverse section of a leaf

Epidermis is the outermost layer. It is a single layer of cells, covering the leaf surface. A waxy substance called **cutin**, which forms the cuticle, covers the upper epidermis. The function of the epidermis is to protect the tissues and to prevent loss of water. On the lower epidermis tiny pores are present called **stomata**. Each stoma is enclosed by two guard cells, having chloroplasts. The **guard cells** control the opening and closing of stoma. Exchange of oxygen and carbon dioxide with the environment and evaporation of water vapour takes place through stomata. Between the two-epidermal layers lies the group of cells called **mesophyll**. These are of two types i.e., **palisade mesophyll** and the **spongy mesophyll**. The palisade mesophyll consists of two or three layers of cylindrical cells. These cells contain many chloroplasts. The spongy mesophyll consists of loosely arranged irregular shaped cells having chloroplast. Large intercellular spaces are present among these cells. This arrangement facilitates diffusion of gases. **Xylem** vessels present in the leaves are long and dead cells. Through xylem cells transportation of water from root to leaves takes place. The **phloem** cells carry the prepared food from the leaf to other parts of the plant.

Activity 4: Study of animal tissues	
Materials required	**Main skills practised**
Compound microscope Prepared slides of sections of animal's epithelial, connective, muscle and nervous tissue Charts of animal's epithelial, connective, muscle and nervous tissue	Following instructions Using microscope Observing slides Making drawings Interpreting results Making conclusions

Introduction

In this activity you will have an opportunity to observe animal tissues. You will identify shape of cells and relate it with function of tissue.

Points for pre-lab discussion
Q.1. What is a tissue?
Q.2. How do animals support their body parts, absorb materials or move?
Q.3. Do you except any "photosynthetic tissue" in animals?
Q.4. What is the location of different tissues in animals?

Procedure

a. You are provided with charts and slides of four types of tissues.
b. Study the features of these tissues from charts.
c. Examine each tissue type one by one under the microscope using the low power lens first and then the high power lens to see greater details.
d. Fill in the following table using the results of your observations.

TISSUE	DIAGRAM: LABEL MAJOR PARTS
Epithelial tissue	
Connective tissue	
Muscle tissue	
Nervous tissue	

SUMMARY

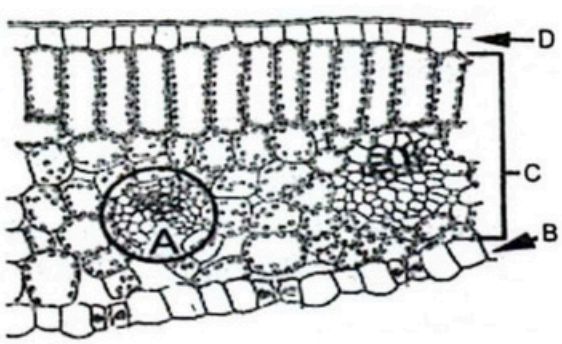
1. Cell organelles are sub cellular structures which work together to form cells.
2. Group of cells with similar functions make tissues.
3. Organs are structures made up of two or more tissues organized to carry out a particular function.
4. Groups of organs with related functions make up different organ systems.
5. All organ system work in a coordinated way to keep the organism living and working.
6. The tendency to maintain a stable, relatively constant internal environment is called homeostasis.
7. Different organ systems of an organism work together to maintain homeostasis.
8. Plant tissues differentiate into three main types: dermal, ground, and vascular tissue.
9. Animal tissues differentiate into four main types: epithelial, connective, muscular and nervous tissue.

EXERCISE

Section I: Multiple Choice Questions

Select the correct answer:

1. The diagram shows cells in part of the leaf of a green plant. Which region contains cells which are responsible for the process of transport?



2. The table shows three functions of cells which row is correct?

	absorption	support	transport
A	red blood cell	muscle cells	root hair cell
B	root hair cell	xylem vessel	red blood cell
C	muscle cell	red blood cell	xylem vessel
D	xylem vessel	root hair cell	muscle cell

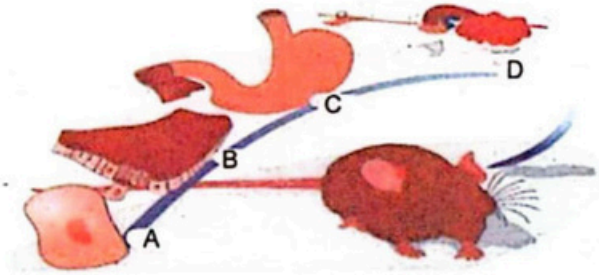
3. What are the functions of xylem and phloem in green plants?

	xylem	phloem
A	support and transport of sugars	transport of water
B	transport of sugars	support and transport of water
C	support and transport of water	transport of sugar
D	transport of water	support and transport of sugars

4. If tissue level is not developed in the level of organization, which next level will not form?

A) Molecular level B) atomic level C) organ level D) organelle level

5. Following diagram shows level of organization in a rat. Which one is the organ level?



6. Which of the following lists the levels of body organization from smallest to largest?

A) organism, organ system, organ, tissue, cell

B) tissue, cell, organ, organ system, organism

C) organ, organ system, organism, tissue, cell

D) cell, tissue, organ, organ system, organism

7. This statement about Homeostasis is incorrect:

A) because of this, the fluctuations of the internal environment are of extremely narrow range as compared to that of the external environment

B) there is one system regulating the homeostatic activities

C) homeostatic mechanisms keep the internal environment constant despite wide changes in the external environment

D) homeostasis is necessary for the survival of cells

8. Which of the following statements best describes homeostasis?

A) keeping the body in a fixed and unaltered state

B) dynamic equilibrium

C) maintaining a near-constant internal environment

D) altering the external environment to accommodate the body's needs

9. Organisms have the ability to change and modify their internal conditions according to the environment through:

A) osmoregulation B) excretion

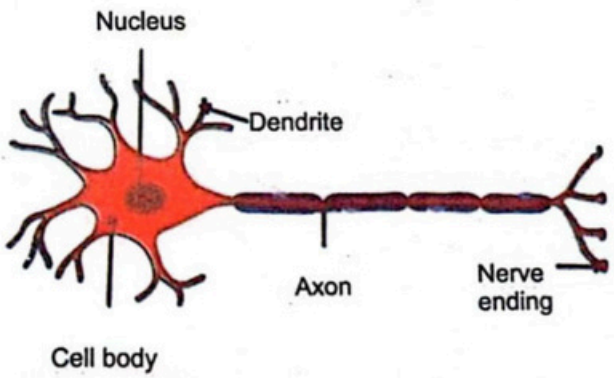
C) thermoregulation D) all of the above

10. You can observe spongy mesophyll and xylem in the section of leaf. These are part of the same:

A) cell and organism B) organ and organism

C) cell and tissue D) tissue and organ

11. The diagram shows a sample of material taken from an organism.



Which level of organization does the sample show?

A) cell B) organ

C) organ system D) tissue

12. Which structure is not an organ?

A) artery B) flower

C) spinal cord D) xylem

13. Which description of xylem is correct?

A) a cell used for absorption B) an organ system used for conduction

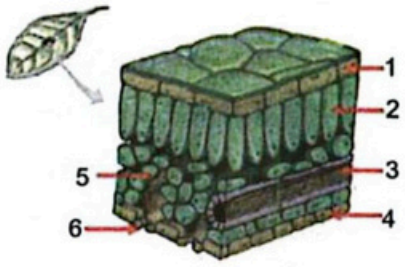
C) a tissue used for transport D) an organ used for transport

14. Which structure is at a different level of organization from the other three?

A) kidney B) liver

C) neuron D) lung

15. The diagram shows tissues from section of leaf. Which type of cells will perform photosynthesis?



A) 1 and 4 B) 2 and 5

C) 2 and 3 D) 3 and 6

Section II: Short Answer Questions

1. Can you differentiate between:

(a) Organ and organelle (b) Animal and plant tissues

(c) Xylem and phloem (d) Epithelial and muscular tissue

(e) Nervous and connective tissue (f) Epidermal and ground tissue

(g) Root and shoot system (h) Vegetative and reproductive part

2. How different tissues form stomach?
3. Why respiratory and cardiovascular systems work together?
4. How temperature is regulated in our body?

Section III: Extensive Answer Questions

1. Justify how the cells of leaf have a variety of specialized structure and function.
2. State the relationship between structure and function of root hairs, xylem vessels and red blood cell.
3. Write a detailed note on animal tissues.
4. Give an account of levels of biological organization.
5. Explain the functions of different organ system of humans.
6. How different organ systems o humans work together to maintain homeostasis?
7. Cells and tissues are adapted to perform their function in the best way. Explain this statement by using example of leaf.